Precision Mapping of Apple Proliferation using Multi- and Hyperspectral Data

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Precision maps have found wide applicability and are predominantly used in precision agriculture which relies on the visual communication of sensor-derived, high-resolution environmental data, to the end-user [1]. However, map-making rests upon generalisation of spatial information, which is commonly overlooked in precision mapping. Hence, despite being treated as a map, contemporary precision maps exist outside of a cartographic framework.

Background

In contrast to traditional plant disease management, plant health monitoring through hyperspectral data enables stakeholders to detect plant stress outside the range of visible light, and thus, at an early disease stage [2]. Early plant disease detection allows minimizing associated crop losses [3], therefore supporting the Sustainable Development Goals and promoting the digital transformation process in agriculture.

Objective

This experimental study aimed at developing a cartographic understanding and methodology for producing precision maps with varying levels of detail to support local, technology-oriented farmers, scientists, and authorities in making spatial decisions. Apple Proliferation (AP), a phytoplasma disease transmitted through insects, served as a case study in the Upper Adige Valley in South Tyrol.

Fig.2 Precision map user interface

Research Questions

1. How can a precision map be defined from a cartographic understanding?
2. Which meaningful spectral bands and vegetation indices from the hyperspectral range can be identified or computed, respectfully, from the spectral signature of a diseased leaf reflecting changes caused through AP?
3. Which machine learning approach produces a robust hyperspectral image classification for identifying and classifying AP at different scales?
4. How can multi-scale data be effectively visualised on various granularity levels?

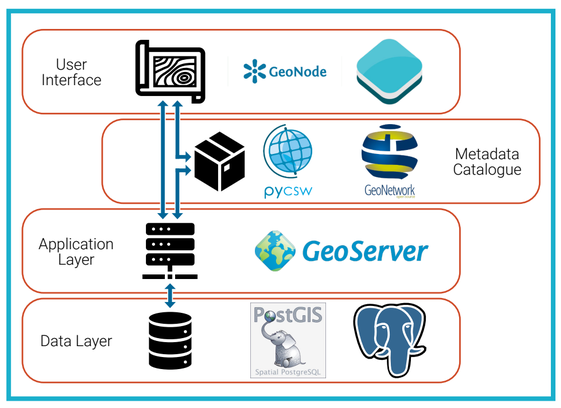

Fig.3 Spatial Data Infrastructure Schema

Results

1. A precision map shall be herewith proposed as being a '*sensor-driven, interactive, thematic map that offers different degrees of granularity at multiple-scales*'
2. Spectral differences could be detected between infected and uninfected trees even at an early disease stage (in May) when symptoms are hardly visible. The spectral ranges from the PCA correlate to photochemical pigments mostly, such as chlorophylls.
3. Further research is necessary, as a black hail net that protects the apple from potential damage caused spatial and spectral distrotions within the aerial imagery.
4. A hexagonal grid structure, assimilating the tree rows, is used for cartographic generalisation of the image classifications as well as for the abstraction of the tree canopy shape by the individual hexagonal cell. Layer visibility settings allow seemless zooming between map layers.

Conclusion

This experimental study is expected to encourage future application of cartography in agriculture and foster cartographic understanding in precision mapping using multi- and hyperspectral data. Further research is required on the spectral analysis of AP, but also in terms of SDI-based collaborative mapping in the agricultural sector, as well as user-oriented precision mapping of plant diseases adopting multi-scale visualisations.

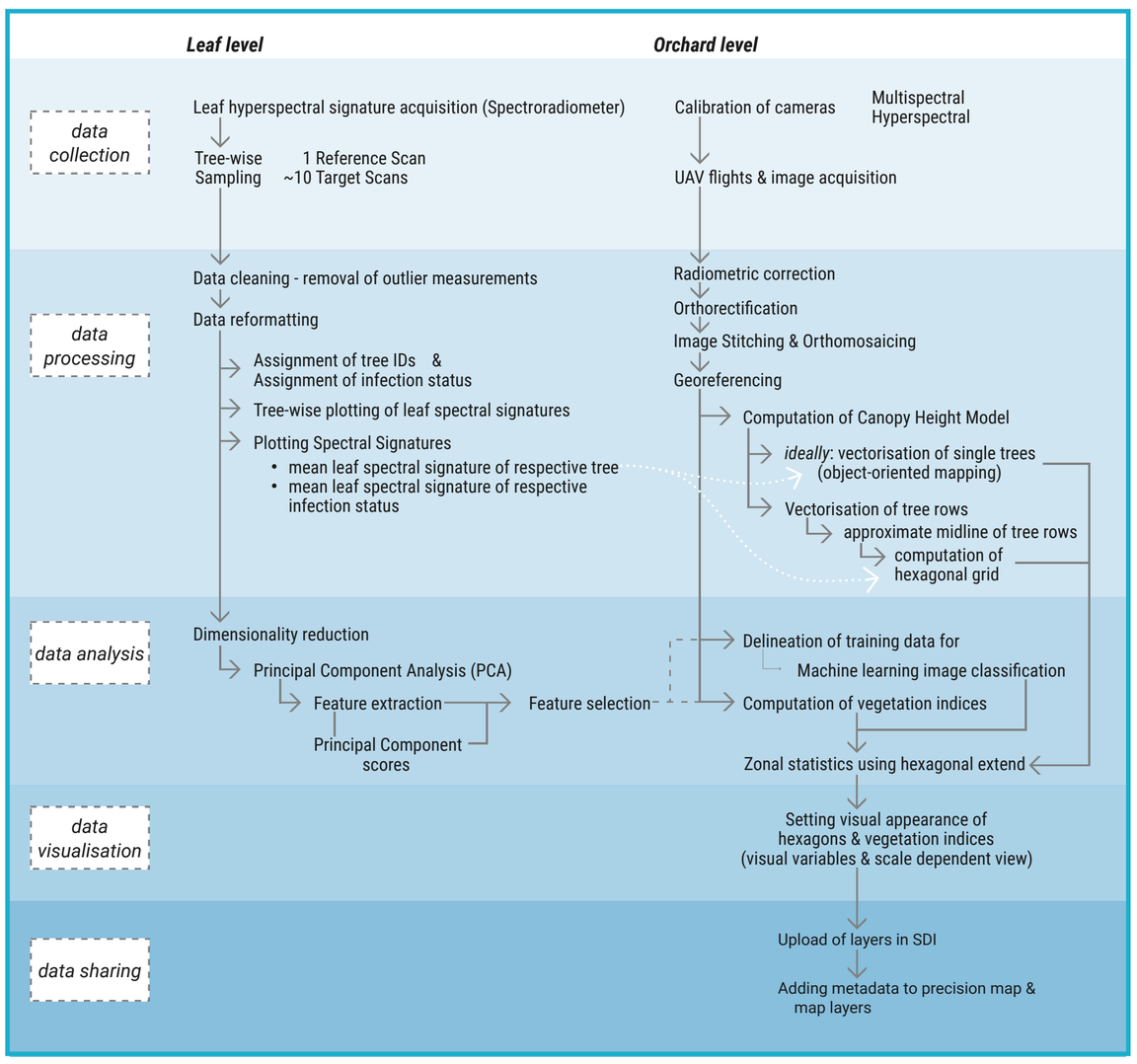

Fig.1 Adopted methodological workflow based on the conceptual framework of the Visualisation Pipeline

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Sensor-Driven Mapping, Plant Disease Mapping, Precision Map, Hyperspectral Data, Agriculture Mapping

References

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